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Genetic Basis for Varietal Improvement of
PIMA COTTONS

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GENETIC BASIS FOR VARIETAL IMPROVEMENT OF PIMA COTTONS[1]

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SUMMARY

Varietal improvement of the extra-long staple cottons in the southwestern United States since 1911 have resulted in a much improved plant type, increased yield, improved fiber quality, and shortening of the fiber while maintaining a high level of yarn strength. Much of the change came about with the development of Pima S-1 and has been extended with Pima S-2, which was released in September 1960.

INTRODUCTION

Seven varieties of extra-long staple cotton, *Gossypium barbadense*, have been grown commercially in the southwestern United States. The first was Yuma, followed by Pima, SxP, Amsak, Pima 32, Pima S-1, and Pima S-2. Yuma (3) [3] was selected from the Egyptian variety, Mit Afifi, and Pima (3) from Yuma. SxP (4) was a selection from a cross of Egyptian Sakel x Pima, Amsak (2) from (SxP) x Sakel, and Pima 32 (2) from Earlipima x Egyptian Giza 7 (table 1). Earlipima was an experimental strain selected from (Sakel x Pima) x Pima. Thus the varieties Yuma, Pima SxP, Amsak, and Pima 32 had a fairly narrow genetic base and they were similar in many respects. These varieties were developed and maintained by a strict pedigree method that resulted in a loss of genetic variability.

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[1] Investigations of extra-long staple cotton in the Southwest are conducted cooperatively by the Agricultural Research Service, U. S. Department of Agriculture, the University of Arizona, the New Mexico Agricultural Experiment Station, and the Texas Experiment Station.

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[3] Figures in parenthesis refer to Literature Cited at end of this report.

Table 1. Commercial Extra-Long Staple Cotton Varieties of Southwestern U. S.

Variety	When Grown	Parentage
Yuma	1911-1918	Selected from an Egyptian variety - Mit Afifi
Pima	1918-1941	Selected from Yuma
SxP	1933-1949	Sakel x Pima
Amsak	1944-1949	(SxP) x Sakel
Pima 32	1949-1954	Earlipima x Giza 7
Pima S-1	1951-	Complex ancestry involving Sea Island, Pima, Tanguis, and Stoneville
Pima S-2	1960-	3-79 x Pima S-1

The Pima S-1 (1) variety differed considerably from the earlier varieties and was developed in a much different manner. Pima S-1 was developed by selection from a complex series of crosses involving Sea Island, Pima, Tanguis, and Stoneville. The first three were representatives of G. barbadense; while the latter was G. hirsutum which probably contributed to the varietal development principally through limited introgression. Pima S-2, released in September 1960, was selected from the cross 3-79 x Pima S-1. The 3-79 parent was from a cross of a sister strain of Pima 32 with Earlipima.

Kerr (5) traced the probable development of the current cultivated varieties of extra-long staple cottons from the center of origin of G. barbadense in South and Central America through the Sea Island, Egyptian, and Pima stages of development (figure 1). The Egyptian varieties were developed at the time when the genetic base was likely to have been broadest. From then through the development of Pima 32 in the United States, this base continued to narrow. With the development of Pima S-1, the genetic base was again broadened, in effect starting the second cycle of re-introducing different germ plasm. In figure 1 the broken lines with arrows show a possible relationship of the parents of Pima S-1 with germ plasm sources.

Each of the four parents of Pima S-1 can be traced to a different source. The Tanguis used as one of the parents of Pima S-1 had long fiber and was day-neutral in flowering habit. This is in contrast to the original Tanguis found in South America, which was short-day in flowering response and had short, coarse fiber. The Tanguis with long fiber possibly came from a cross between the short, coarser fibered Tanguis from South America and a long, fine fibered Egyptian cotton.

1960 TEST OF EXTRA-LONG STAPLE COTTON

Reserve seed of Pima, SxP, Amsak, Pima 32, Pima S-1, and Pima S-2 were increased sufficiently to grow a replicated performance trial of the six varieties at the Cotton Research Center, Tempe, Ariz., in 1960. Results from this test are given in table 2. The superiority of Pima S-2 in yield and lint percentage is evident. The mean yield and lint percentage of Pima S-2 were significantly higher than Pima S-1, the most recent commercial variety.

The fiber properties of the varieties included in this test also revealed definite trends. Figure 2 shows the upper-half-mean length, mean length, T_1 strength, fineness, and strength of 22's yarn of each variety plotted on a percentage scale with Pima S-1 values set at 100 percent. The four older

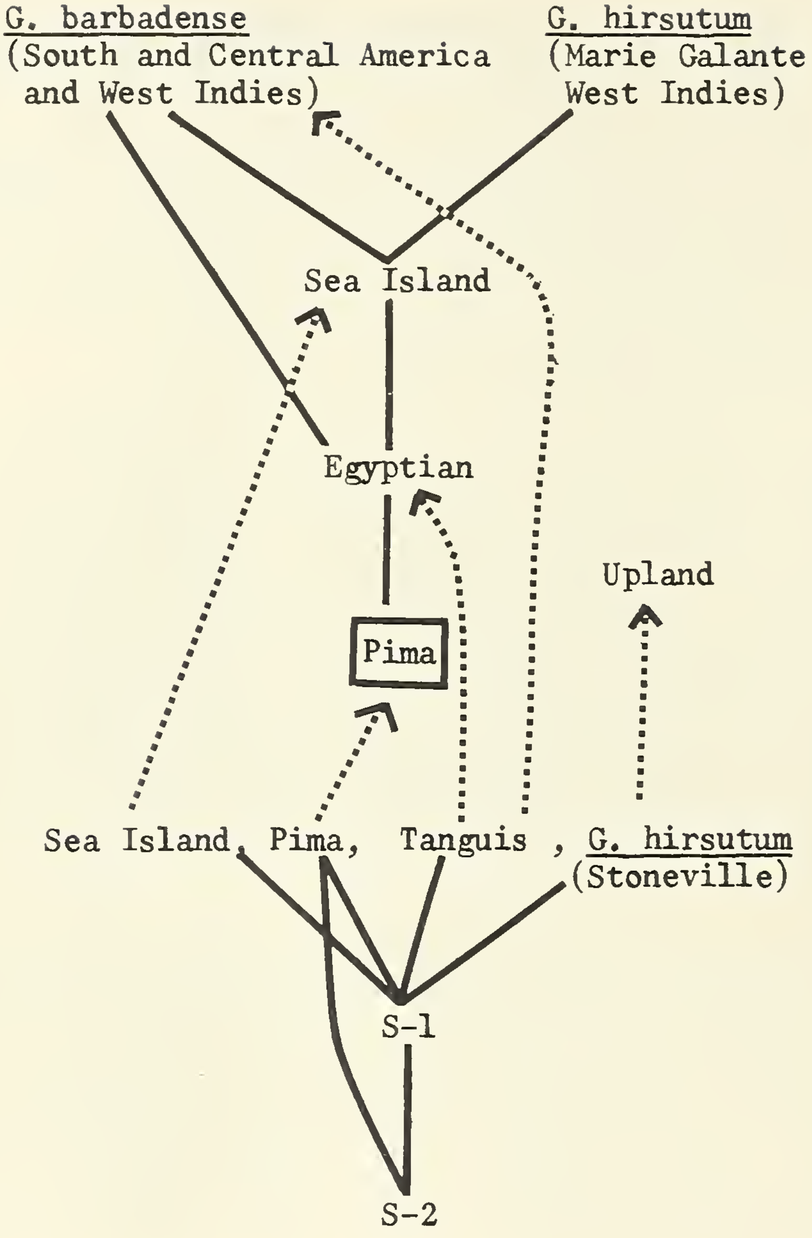

Figure 1. Schematic representation of the development of *G. barbadense* varieties.

Table 2. Lint Yields, Lint Percentages, Fiber Properties and Yarn Strengths of Six Extra-Long Staple Cotton Varieties Grown at Tempe, Arizona, 1960.

Variety	Yield Lbs. Lint Per Acre	Lint %	U.H.M.	Mean	T_1	Micronaire	22's
Pima	280	25.1	1.50	1.26	26.9	3.77	162
SxP	433	27.3	1.48	1.27	28.2	3.61	173
Amsak	393	27.4	1.50	1.28	30.2	3.56	185
Pima 32	429	26.7	1.48	1.23	30.1	3.49	178
Pima S-1	471	31.5	1.39	1.20	29.9	3.77	178
Pima S-2	650	32.9	1.39	1.19	30.6	3.80	178
L.S.D., .05	53	0.5	0.02	0.03	0.8	0.15	7
L.S.D., .01	72	0.7	0.03	0.04	1.0	0.20	10
C.V.	10.0%	1.5%	1.3%	1.9%	2.2%	3.4%	2.2%

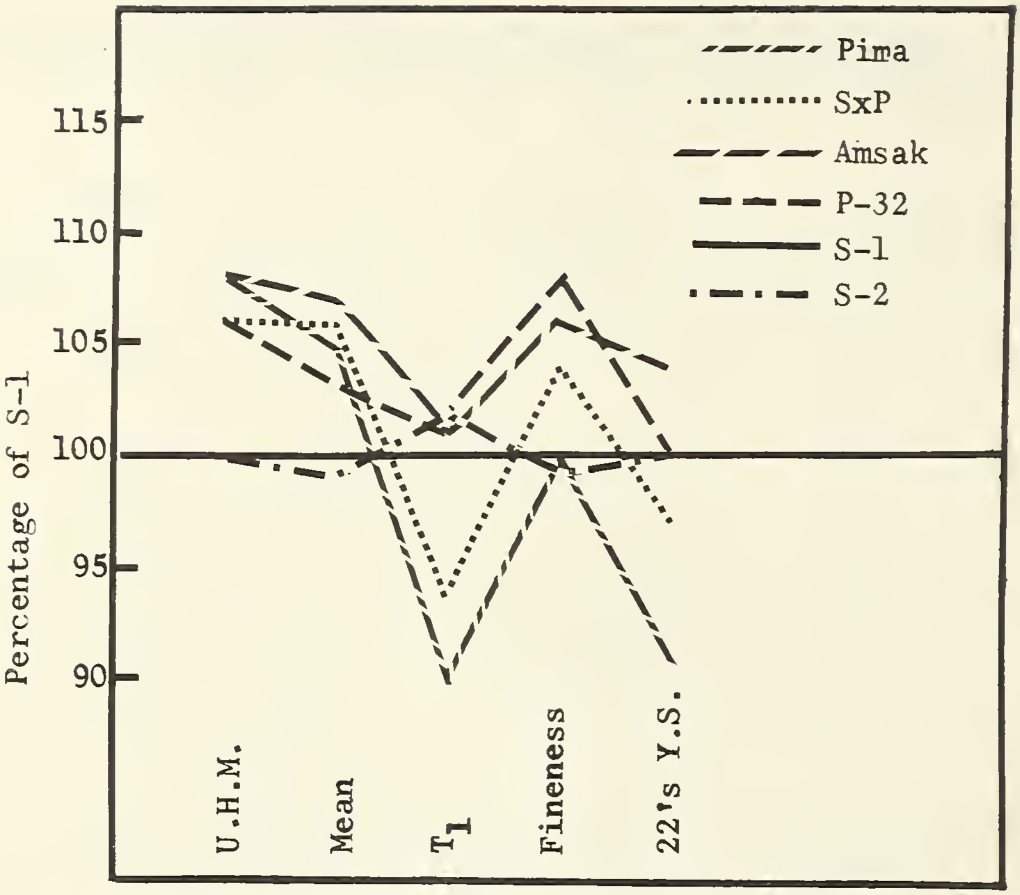

Figure 2. Fiber properties and spinning performance of six extra-long staple varieties, expressed as percent of S-1, 1960.

varieties (Pima, SxP, Amsak, and Pima 32) had longer fiber, but varied in fiber strength, fiber fineness, and yarn strength relative to Pima S-1. Pima and SxP had relatively weak fiber and low yarn strength, whereas Amsak showed a noticeable improvement in fiber and yarn strengths. Pima 32 had a slightly lower yarn strength than Amsak, but was superior to it in yield and other agronomic properties.

Pima S-1 is considered a new base point in the extra-long staple improvement program. Its fiber is shorter and coarser than that of the previous extra-long staple varieties, but it has a yarn strength greater than might be expected on the basis of its fiber properties. The calculated yarn strengths 4/ vs. strengths of microspun 22's yarn for Pima 32 and Pima S-1 from one test in 1955 and four tests in 1956 are shown in figure 3. Pima 32 and Pima S-1 showed little difference in calculated yarn strengths; however, the actual strength of Pima S-1 is higher. This possibly indicates that Pima S-1 has an unknown factor contributing to yarn strength which Pima 32 does not possess.

Although plant height can be varied considerably by environment, height differences among these six varieties were obvious. Pima and Amsak plants were tallest, followed by SxP, Pima 32, Pima S-1, and Pima S-2 in a decreasing order of plant height. The development of the less rank extra-long staple cottons has resulted in striking changes in production practices. The earlier varieties were grown with wide spacing (12 to 18 inches), with limited irrigation (especially prior to fruiting), and on light soils with practically no nitrogen fertilizer. Presently, the extra-long staple varieties are grown under cultural practices similar to those now used for the Upland varieties, although for best results on most soils slightly less water and fertilizer should be used with the extra-long staple varieties.

DEVELOPMENT OF PIMA S-2

Pima S-2 is a selection from the cross 3-79 x Pima S-1. It was a logical step when Pima S-1 was developed to cross it with the best available breeding material for further

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4/ The formula used in calculating yarn strength was developed by Dr. Paul Fryxell, Agricultural Research Service, University of Arizona Cotton Research Center, Tempe, Ariz., from breeding strains grown in 1957. The formula is: Calculated yarn strength = $16.8329 + 28.4026\ \text{UHM} + 32.1423\ T_1 + .054606\ A$.

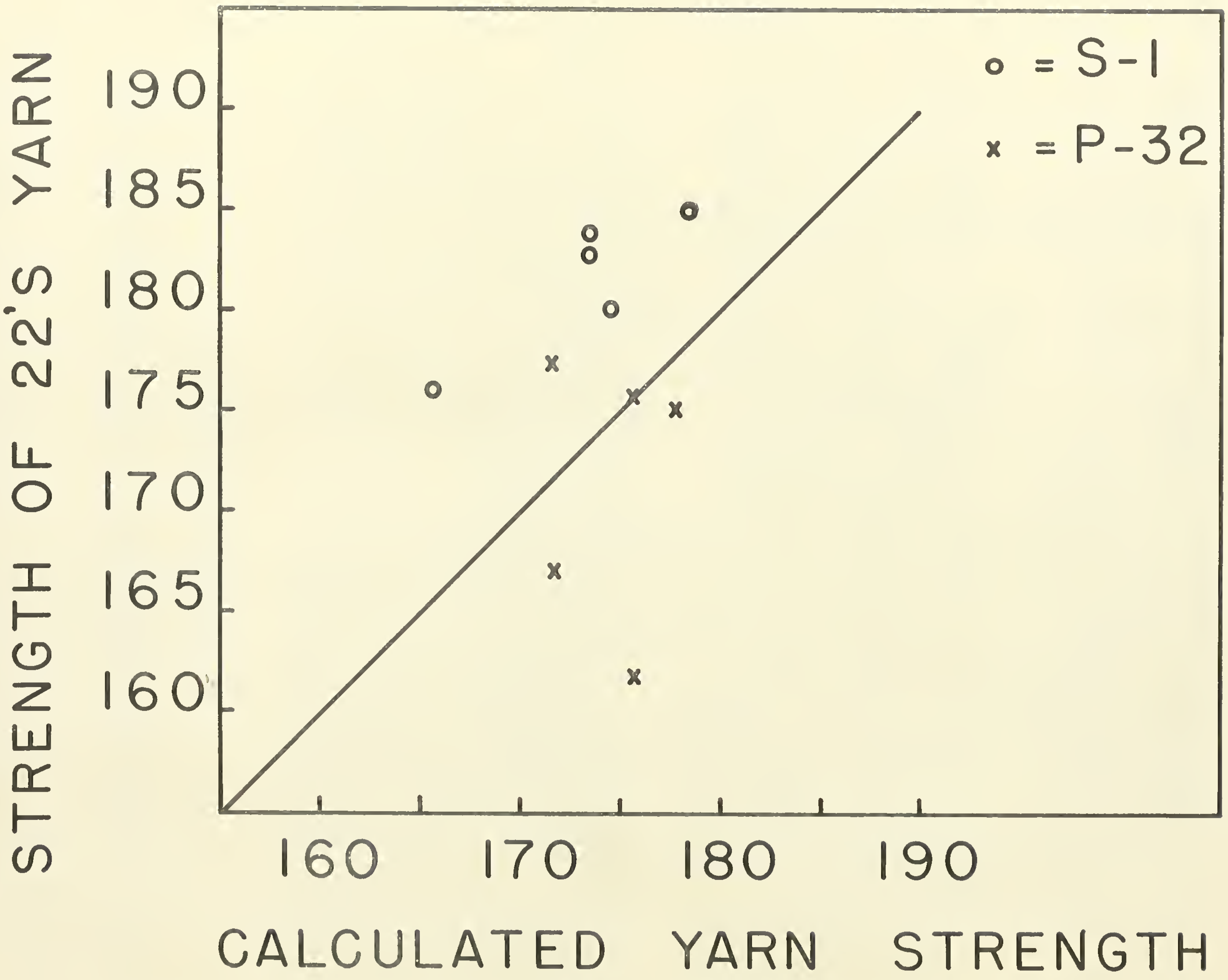

Figure 3. Calculated yarn strength vs. strength of 22's yarn.

improvement. In 1951, Pima S-1 was crossed with Pima 32 and 3-79. Numerous strains were derived from Pima 32 x Pima S-1, and somewhat fewer strains derived from 3-79 x Pima S-1. In 1956-57, three yield tests were made on six strains from the 3-79 x Pima S-1 cross and on sixteen strains from the Pima 32 x Pima S-1 cross. The relationship of the average yields of these strains and Pima S-1 with the microspinning results from 1955 is shown in figure 4. The strains from the Pima 32 x Pima S-1 cross were relatively low yielding; however, they had high yarn strengths. The strains from 3-79 x Pima S-1 were high yielding, but were somewhat weaker. The average yield of Pima S-1 was 709 pounds of lint per acre as compared with 861 pounds for the highest yielding experimental strain. The graph indicates that some compromise must be made when selecting the most desirable strain for a possible future variety. Actually, the strain that was later chosen as the new release, Pima S-2, was neither the highest yielding strain nor the strongest. It was the strain that had a 22's yarn strength of 187 pounds compared to 192 for Pima S-1 and a yield of 846 pounds compared to 709 for Pima S-1.

The strength of microspun 22's yarn as related to fiber properties (calculated yarn strength) for 28 Pima S-1 strains, 16 strains from the Pima 32 x Pima S-1 cross, and 6 strains from the 3-79 x Pima S-1 cross is shown in figure 5. Regression lines were established for the 28 Pima S-1 strains and for the 22 strains from the two crosses. The slopes were essentially the same for the two groups of strains; however, the regression line for the Pima S-1 strains was to the left, showing that these strains as a group spin better than their fiber properties indicate. The regression coefficients for the Pima S-1 strains and the strains from the two crosses were highly significant. The spinning performance as related to fiber properties of the strain released as Pima S-2 was the same as the average of the strains from the two crosses.

The fiber properties and yarn strength of Pima S-2 are similar to those of commercial Pima S-1. Thus, the ability of Pima S-1 to spin better than its fiber properties indicate appears to have been at least partly transferred to Pima S-2. Recovery of this undetermined spinning property was possible only by the use of both fiber testing and spinning evaluation.

COMPARISON OF PIMA S-1 AND PIMA S-2, 1956-60

Data have been accumulated over a 5-year period, 1956-60, comparing Pima S-2 with Pima S-1 (table 3). Pima S-2 maintained a 16 percent mean yield advantage over Pima S-1 in 25 tests during this period. An average of 14 percent was shown in 8 tests in 1960, 30 percent in 5 tests in 1959, 7 percent

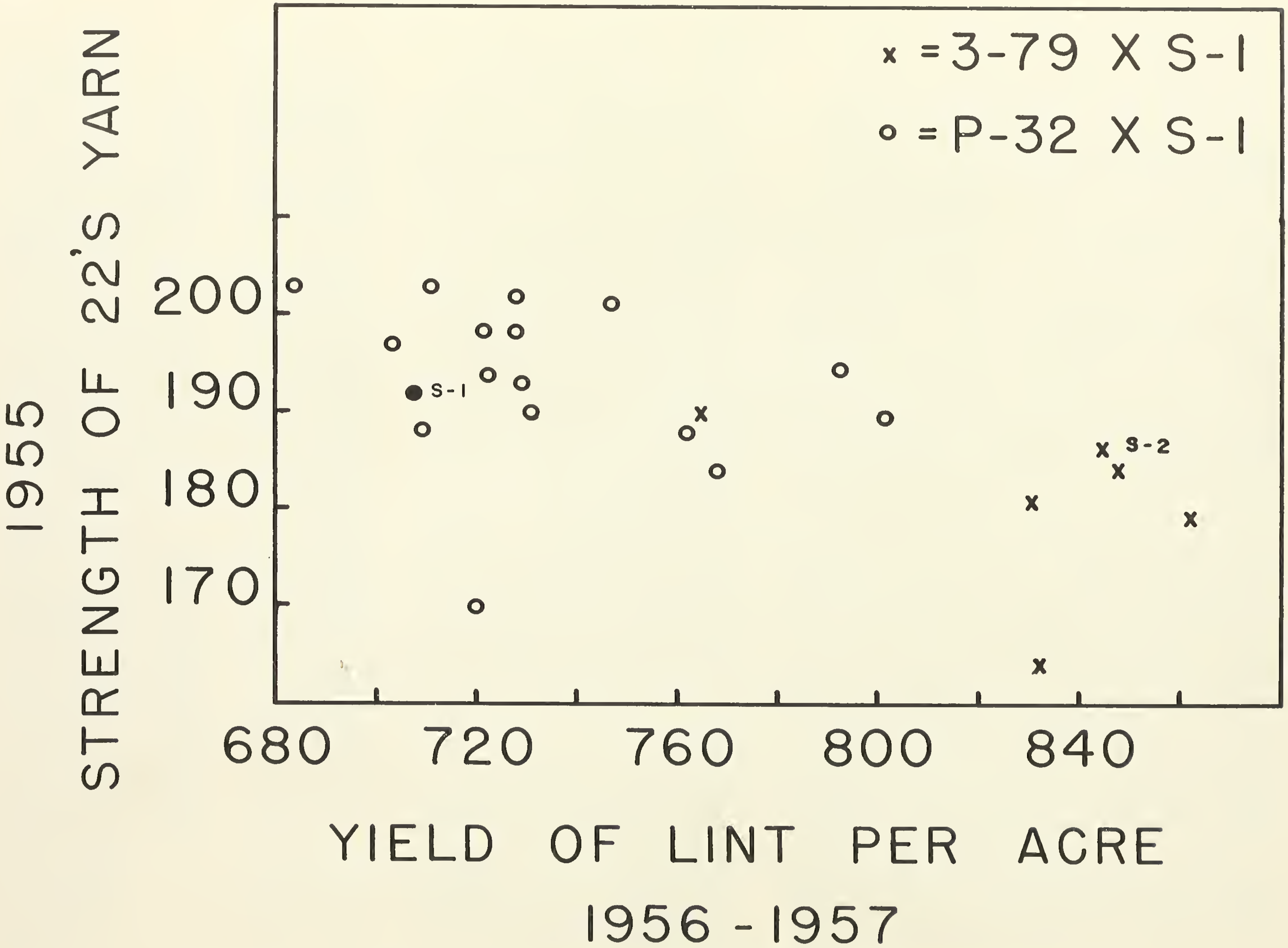

Figure 4. Yield vs. strength of 22's yarn for breeding strains and S-1.

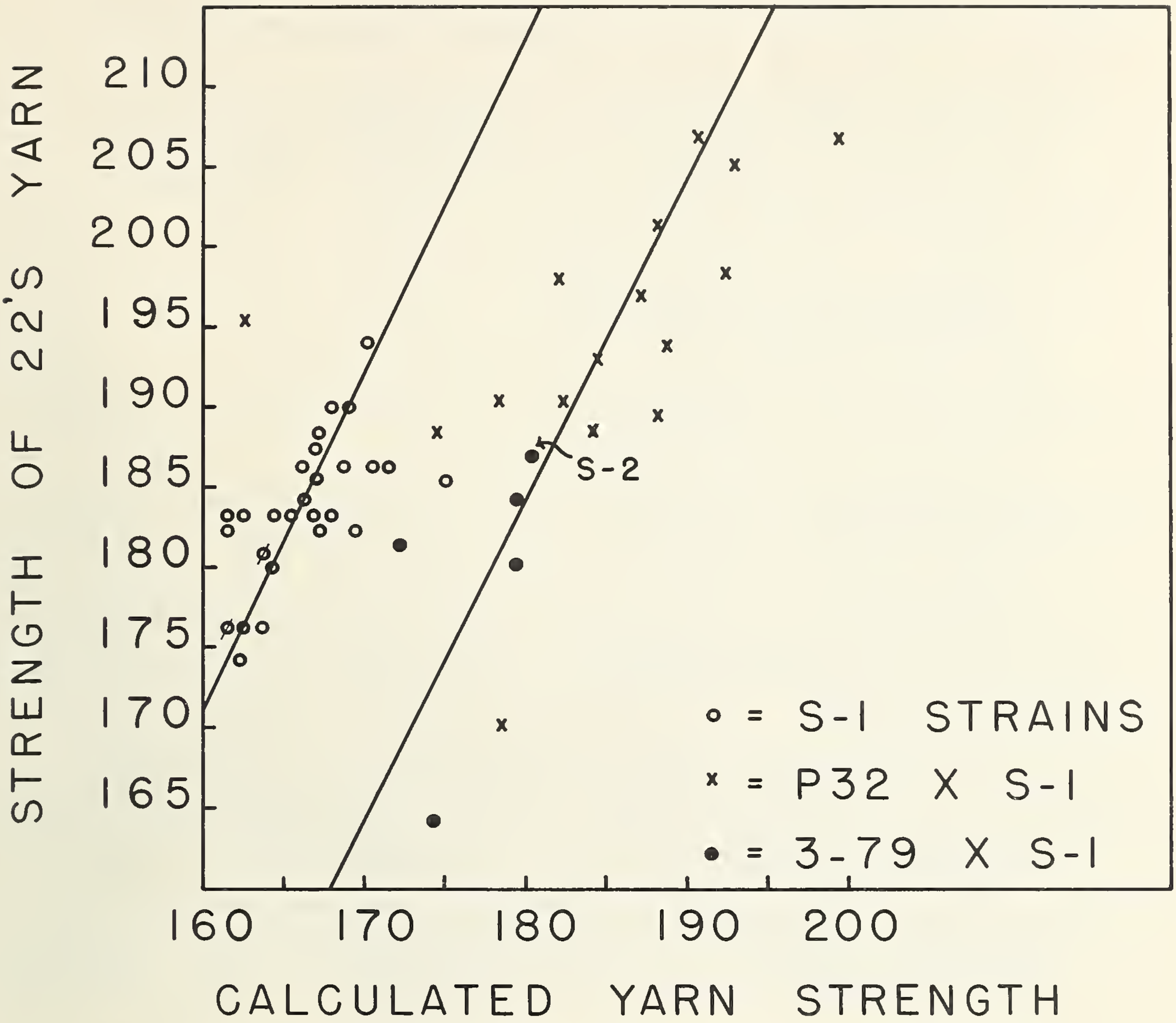

Figure 5. Calculated yarn strength vs. strength of 22's yarn.

Table 3. Comparison of Pima S-2 with Pima S-1, 1956-60.

Characters Measured	Number of Tests	Pima S-1	Pima S-2
Yield (pounds of lint per acre)	25	702	804
Yield (yield of S-2 in each test calculated as percent of S-1 and averaged	25	100	116
Earliness (percent of cotton harvested at first pick)	19	59.4	65.8
Number of Bolls Per Pound of Seed Cotton	21	125	129
Lint Percentage	21	34.0	36.0
Upper Half Mean Fiber Length	21	1.34	1.34
Mean Fiber Length	21	1.14	1.13
Fiber Fineness (Micronaire)	16	3.50	3.79
Fiber Strength 1/8" Gauge (grams per tex)	19	29.6	30.0
Skein Strength (pounds)			
36s Combed Yarn	12	110	107
60s Combed Yarn	12	59	57
Yarn Appearance Index	12	121	125
Neps Per 100 Square Inches of Card Web	12	6.0	4.8
Waste Percentage			
Carded 4-1/2 lbs./hr.	12	11.13	9.42
Comber	12	11.43	11.46

in 5 tests in 1958, 17 percent in 5 tests in 1957, and 16 percent in 2 tests in 1956. Although yield advantages were shown at all elevations where tests were grown, the highest yield advantages were obtained at the lower elevations where Pima S-2 sets a much better bottom crop than Pima S-1. No difference in the bottom set of the two varieties occurs at the higher altitudes. Eleven of the 25 tests were grown at elevations of 1,400 feet or below, with an average yield for Pima S-2 of 25 percent above Pima S-1 (table 4). Fourteen of the tests were grown at 2,000 feet or above, with an average advantage for Pima S-2 of 10 percent above Pima S-1. Pima S-2 is earlier maturing, has a higher lint percentage, and has fiber properties similar to those of Pima S-1 except for a slight increase in micronaire value.

In spinning tests conducted at the Agricultural Marketing Service Spinning Laboratory, Clemson, S. C., the performance of Pima S-2 was satisfactory. It has a yarn strength slightly below Pima S-1; but it has better yarn appearance, fewer neps, and less waste in spinning. The strength determinations reported by the Clemson Laboratory are in complete agreement with the earlier microspinning results from the Agricultural Research Service Microspinning Laboratory, Knoxville, Tenn.

Other Pima S-2 characteristics not indicated in table 3 are its shorter and more compact plant, faster ginning rate, and lack of requirement for hot-water treatment of the planting seed for improved germination (6). Pima S-2 germinates and emerges more rapidly than Pima S-1 even when Pima S-1 is hot-water treated and Pima S-2 is untreated. Pima S-2 has substantially less seed fuzz than Pima S-1 and tests show that the ginning rate of Pima S-2 is as much as one-third faster than that of Pima S-1. 5/

5/ Personal communication, Chapman, W. E., Jr.

Table 4. Yield Comparisons of Pima S-2 and Pima S-1, 1956-60.

Year	Location	Approximate altitude (feet)	Yield (Pounds per acre) S-2	S-1	Yield of S-2 expressed as percent of S-1
1956	Tempe, Ariz.(1)	1,200	804	747	108
	Tempe, Ariz.(2)	1,200	896	721	124
1957	Yuma, Ariz.	100	1,199	1,064	113
	Tempe, Ariz.(1)	1,200	839	717	117
	Tempe, Ariz.(2)	1,200	1,068	919	116
	Ysleta, Tex.	3,800	646	589	110
	Canutillo, Tex.	3,800	522	404	129
1958	Yuma, Ariz.	100	1,009	882	114
	Tempe, Ariz.	1,200	761	592	129
	Marana, Ariz.	2,000	779	705	110
	Safford, Ariz.	2,900	932	1,035	90
	Las Cruces, N.M.	3,900	560	614	91
1959	Tempe, Ariz.	1,200	654	447	146
	Coolidge, Ariz.	1,400	652	445	147
	Safford, Ariz.(1)	2,900	1,081	910	119
	Safford, Ariz.(2)	2,900	1,000	858	117
	Ysleta, Tex.	3,800	418	346	121
1960	Yuma, Ariz.	100	926	736	126
	Tempe, Ariz.	1,200	780	571	137
	Marana, Ariz.	2,000	669	555	121
	Safford, Ariz.(1)	2,900	1,162	1,107	105
	Safford, Ariz.(2)	2,900	987	956	103
	Fabens, Tex.	3,800	449	436	103
	Ysleta, Tex.	3,800	523	543	96
	Las Cruces, N.M.	3,900	772	657	118

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